MARKET OPPORTUNITIES FOR LSI - VLSI

COMPUTER - AIDED DESIGN PRODUCTS AND SERVICES

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MARKET OPPORTUNITIES FOR LSI/VLSI COMPUTER-AIDED DESIGN PRODUCTS AND SERVICES

Prepared For:

CONTROL DATA CORPORATION

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JULY 1980

MARKET OPPORTUNITIES FOR LSI/VLSI COMPUTER-AIDED DESIGN PRODUCTS AND SERVICES

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MARKET OPPORTUNITIES FOR LSI/VLSI COMPUTER-AIDED DESIGN PRODUCTS AND SERVICES

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1 INTRODUCTION

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I INTRODUCTION

- The primary objectives of this study are to determine the projected market through 1985 for Computer-Aided Design (CAD) systems and services used for the design of LSI/VLSI devices.

- The CAD methods currently being employed by VLSI circuit designers today are examined as well as designers' perceptions of preferred new methods available in the forecast timeframe.

- Results of the study are presented in order to identify market opportunities and business strategies offering the greatest potential for the Control Data Corporation in the 1980-1985 timeframe.

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II SCOPE AND METHODOLOGY

II SCOPE AND METHODOLOGY

A. SCOPE

- The research conducted in this report primarily addresses the industry-wide problem - and market opportunity - of developing computer-aided design systems capable of handling the enormous complexity of VLSI circuit projected for the 1980-1985 timeframe. Future CAD systems must relieve through automation what will otherwise become a limitation on industry growth imposed by the complexity of VLSI circuits and the scarcity of circuit designers.

B. METHODOLOGY

- Fifteen interviews were conducted with VLSI computer-aided design users and vendors located primarily in the "Silicon Valley" of the San Francisco Bay Area. The CAD Interview Program is shown in Exhibit II-1.

  - Twelve of the 15 interviews were conducted on-site, which exceeded the original plan considerably and gave a more solid basis for the research findings presented in this report.

  - The user interviews included system companies, computer vendors, computer peripheral manufacturers, semiconductor manufacturers, and a major university.

EXHIBIT II-1

CAD INTERVIEW PROGRAM

INTERVIEW TYPE	NUMBER OF RESPONDENTS	TELE-PHONE / ON-SITE	SIZE OF COMPANY		
			SMALL	MEDIUM	LARGE
VENDOR	2	– / 2	1	1	–
USER	13	3 / 10	3	7	3
TOTAL	15	3 / 12	4	8	3

SMALL = < $100 MILLION REVENUE
MEDIUM = $100 - $1,000 MILLION
LARGE = > $1 BILLION

- Interviews were divided by revenue categories.

  . Large: more than $1 Billion.

  . Medium: $100 - $1,000 Million.

  . Small: less than $100 Million.

III EXECUTIVE SUMMARY

A. CHARACTERISTICS OF THE MARKET

- The integrated circuit industry, growing at a rate of 25% per year, is entering the era of very large scale integration (VLSI).
  - VLSI circuits double in complexity every year creating enormous problems for the industry.
- Total systems can now be placed on a single chip.
  - The 1 million device chip is expected by 1985.
- Highly automated methods (CAD) will be used in all phases of the design process. Computer-aided design systems will also generate test and fabrication data as the design proceeds.
  - Although industry demand for CAD is very high, present systems are woefully inadequate.
  - Present CAD systems can handle only 10% of the VLSI circuit design requirements.

- Design times for present VLSI devices are measured in tens or even hundreds of person years.

  - There are only 2,000 VLSI circuit designers in the country today.

  - Unless CAD methods are improved dramatically, the design process itself will constrain industry growth.

- The computer-aided design market for LSI/VLSI has been the province of relatively small companies, notably:

  - Calma.

  - Applicon.

  - Computervision.

- The industry is in a state of euphoria because of the very rapid growth in the market, but also in a state of shock because of the extreme difficulty the small companies have in meeting market needs. Great stress has been placed on these little companies.

  - The CAD systems are inadequate for design of VLSI circuits.

  - Software is a problem.

    . Processing times are too long.

    . Documentation is poor.

    . Vendors' response to enhancements is poor.

  - Maintenance is a problem.

- From other research, INPUT has determined that current vendors of freestanding CAD/CAM are providing a level of maintenance service well below the normal expectations of users of data processing equipment.

- One respondent company, a knowledgeable industry source, stated that it would never buy again from any of the top three CAD vendors because their products were not far enough advanced to be useful and because the vendors were not making sufficient advancement in the state of the art of their designs.

- INPUT believes that a structured approach by a large company like CDC could have a major impact on the market.

- Management of companies in the LSI/VLSI field are very concerned over the state of affairs in CAD.
  - Unless the problem is solved, future development of the VLSI industry will be severely constrained.

- The whole CAD problem represents a competitive threat to U.S. VLSI vendors because the Japanese have been very active in improving CAD methods for use in their own industry.
  - If the Japanese achieve a superiority in design methods, and hence in circuitry, U.S. industry would not be competitive and would lose in market share.

- Typical users' comments are:
  - "CAD is a requirement. Without it, existing products would be impossible, and growth obviously would not be considered.

- "Crack people can design chips now without CAD, but we need CAD so that all designers can make it or we will lose out to the Japanese."

B. USERS' EXPENDITURES FOR CAD

- Users' expenditures for CAD are large and rapidly growing.
  - Exhibit III-1 shows present expenditures for computer-aided design for LSI/VLSI devices, as reported by respondents.
  - CAD expenditures of 15% of R&D expense ranging up to $10 million per year are clear evidence of the industry's need.

C. NEW CAD METHODS

- The CAD systems needed for VLSI are not likely to be developed by "brute force" methods which would lead to intolerable personnel and computer requirements. The answer must come from the sophistication that developed VLSI itself.
  - Major and rapid changes in CAD systems are expected over the next five years.
  - The combined efforts by industry, universities and government to improved CAD methods is comparable to those that developed the VLSI process itself.
- The research and development efforts in industrial firms can be classified as being evolutionary in nature. The university efforts, supported by government funding, are largely focused on achieving revolutionary results.

EXHIBIT III-1

PRESENT EXPENDITURES FOR
COMPUTER-AIDED DESIGN FOR LSI/VLSI DEVICES
AS REPORTED BY RESPONDENTS

CAD EXPENDITURES	TOTAL SALES	R&D EXPENSE	CAD EXPENSE
AVERAGE (PERCENT)	100%	10% OF SALES	15% OF R&D EXPENSE OR 1.5% OF SALES
TYPICAL COMPANY-($ MILLION)	$500	$50	$7.5

- One major goal is to reduce processing time by improving software packages.

  . University researchers believe that it may be possible to run in a matter of minutes programs that now take hours or even days.

- A second major goal is to reduce design time in terms of labor expended along with lowering the required level of sophistication of VLSI circuit designers.

- The major universities involved are:

  . Cal Tech

  . Stanford

  . U.C. Berkeley

  . Carnegie Mellon

  . MIT

- Typical users' comments are:

  - "Every major university in the nation will be working on CAD. There were 33 new ones in 1978 and 1979."

  - "The universities will make it tough on CAD vendors. There are 30 universities giving their software away, each one takes an area in which to excel."

D. VLSI TECHNOLOGY

- The VLSI market is now "driven" by consumer applications.
  - In 1980, the number of chips being produced is about equally divided between custom and standard.
  - By 1985, about 70% of the chips produced will be standard while the rest will be custom circuitry.
- The two VLSI technologies, bi-polar and metal oxide semiconductors (MOS) are comparable in terms of speed, performance and even cost.
- However, N-MOS and its high-performance successor, H-MOS, are most commonly used.
- Meanwhile, Complementary-MOS (C-MOS) is catching up rapidly.
  - C-MOS combines both P-channel and N-channel devices on the same N substrate.
  - C-MOS devices have an important advantage. The devices draw virtually no power in the quiescent state, using significant amounts of energy only while switching.
- C-MOS is slated to be the dominant technology in the 1980-1985 timeframe.
  - Its properties make it well suited for both commercial and systems applications.
- Gallium Arsenide (GaAs) represents the next major improvement in performance over silicon technology.

- Development efforts continue on GaAs. It will see limited applications in the 1980-1985 timeframe where special applications demand higher performance.

E. MARKET SIZE AND GROWTH

- Rapid growth of the market for computer-aided design systems for LSI/VLSI systems is assured over the 1980-1985 timeframe.

  - The CAD market is driven in part by growth in the LSI/VLSI industry which it serves.

    . Historical records show that the LSI/VLSI industry is growing at 25% per year.

  - The total production of integrated circuits (including in-house captives) for world markets by U.S.-based manufacturing companies will be $8.6 billion in 1980, reaching an expected $26 billion in 1985.

    . The total number of chips will go from 8 billion in 1980 to 18 billion in 1985.

  - Three knowledgeable respondents judged the CAD market growth to be from 30-50%.

  - Almost all respondents felt that the future CAD market could not be extrapolated from past performance, but rather that there would be discontinuous or "explosive" growth.

  - Considering all of these factors, as well as other INPUT research, the growth rate in computer-aided design for LSI/VLSI circuitry is forecast to be an AAGR of 50%.

- The market forecast for LSI/VLSI computer-aided design systems and services is shown in Exhibit III-2.

  - The market will grow exponentially, reaching over $900 million in 1985.

- Past and current efforts of CAD vendors have been aimed more at mechanical than electrical applications.

  - Consequently, the mechanical market has shown larger growth than the electrical.

  - The CAD products are able to serve the needs of mechanical design but not for electrical design, which also accounts for slower growth in the electrical market.

- However, future projections are another story. Assuming that rapid advances are made in electrical CAD as a result of the large research and development efforts, future growth in the electrical market is likely to outstrip growth in the mechanical market.

  - This is so because users will have to keep up with the leading edge of the technology to stay competitive and because product life cycles will be short.

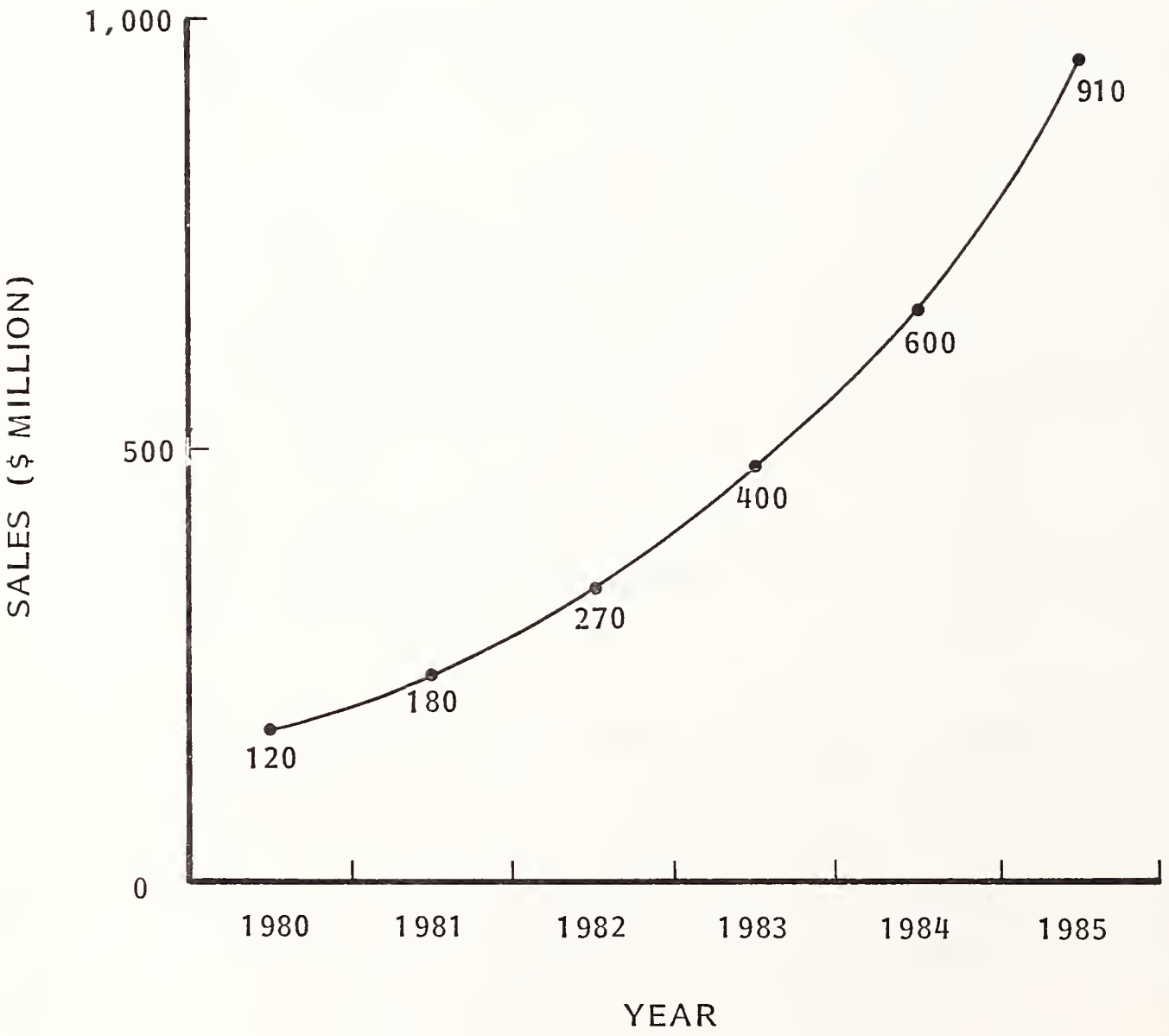
- Throughout this study, respondents have consistently expressed an overwhelming preference for freestanding systems over computer services.

  - Based on the results of this study and other related research, INPUT estimates that 85% of the market will be for turnkey or freestanding systems and 15% will be for computer services.

- Depending on the approach, CDC should be able to penetrate the LSI/VLSI CAD market by 5%.

EXHIBIT III-2

MARKET FORECAST -
LSI/VLSI COMPUTER-AIDED DESIGN
SYSTEMS AND SERVICES



AAGR = 50%

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- This would result in new CAD business for CDC of $45 million per year by 1985.

F. CONCLUSIONS

- Computer-aided design for LSI/VLSI is a major issue. The industry must expand its efforts or lose market share to the Japanese.
- The CAD market will experience "explosive" growth over the 1980-1985 timeframe.
- Present CAD systems are primitive and must be greatly improved.
- Changes will come rapidly and short product life is to be expected.
- The industry must stay on the forward edge of technology to stay competitive.
- Government-sponsored university research in CAD is important and is expected to result in major software improvements.
- C-MOS will evolve as the dominant technology in the 1985 timeframe.
- Total integrated systems and data base management are key.
- Future CAD systems will involve multiple CAD installations tied together in a satellite configuration connected to a host or RCS computer.

G. RECOMMENDATIONS

- Control Data Corporation should investigate the substantial university-based CAD/CAM research effort for LSI/VLSI design.

- The work is being sponsored by the federal government so results will be in the public domain.

- The need is to determine:

  . Expected major improvements in hardware and software areas in CAD/CAM that will allow order-of-magnitude improvements in design methods.

  . The timeframe in which results will be available.

  . The transferability of research results to industrial use.

  . How CDC can link into this national effort in order both to keep its CAD/CAM products up with leading-edge technology and to maintain a competitive edge.

- CDC should consider a multifunctional CAD/CAM research, development and marketing effort for LSI/VLSI devices, an effort presently involving multiple vendors.

  - Total corporate strengths should be brought to bear on the industry problem with an effort aimed at displacing current multiple vendors.

  - A totally integrated system, a true CAD/CAM for LSI/VLSI, should include the following:

    . Chip design, particularly emphasizing the most important applications of design rules checking, layout, simulation and data base management.

    . Fabrication data, including production of photomasks.

    . Sustaining engineering.

  - Receiving inspection.
  - Auto-insertion.
  - Auto chip testing.
  - Superior field maintenance.

- An integrated system will involve multiple CAD/CAM installations tied together in a satellite configuration connected to an in-house host or RCS computer center, an "in-plant communications highway."

- CDC should pursue a product development course that will result in a total services offering including:

  - Freestanding in-house installations based on OEM minicomputers.
  - In-house host communications to satellite installations.
  - Remote computing services through the network.
  - Superior field maintenance.
  - Data base management for a totally integrated system.

- CDC should identify joint-venture and acquisition candidates for:

  - Joint ventures with universities to transfer the new technology.
  - Joint ventures with I.C. industry for LSI/VLSI design applications and manufacturing automation.
  - Acquiring CAD firms.

- CDC marketing efforts should stress the newest technology and be aimed at universities as well as industrial users as potential customers.

IV MARKET ANALYSIS AND FORECAST

IV MARKET ANALYSIS AND FORECAST

A. THE PRESENT ENVIRONMENT

- As the semiconductor industry enters the era of Very Large Scale Integration (VLSI), vendors must be concerned not only with what kind of devices to manufacture and how to make them, but also with what design methods to use.

  - Highly automated methods to coordinate system design and chip fabrication will be required.

  - Computerized design systems must be used in all phases of the design process. These systems will also generate test and fabrication data as the design proceeds.

- The industry is developing the capability to produce a 1 million device chip by 1985, an order of magnitude increase. This implies an enormous increase in complexity.

  - Even with today's VLSI products, design times are measured in person years.

  - With only about 2,000 VLSI circuit designers in the country today, future growth of the industry will be constrained unless design tools are improved dramatically.

- The design issue is not being ignored, as it truly represents a competitive threat. The Japanese are well advanced in CAD. The U.S. industry must solve the problem or lose market share.

- Present computer-aided design systems fall far short of current design needs, let alone their inability to cope with the enormous increase in complexity that will come in the next few years.

  - Typical repondent's comments concerning the adequacy of present VLSI computer-aided design systems are shown in Exhibit IV-1.

  - Users' comments reflect the fact that present CAD systems are primitive when compared to industry needs in the 1985 timeframe. Eleven out of 13 respondents found present systems inadequate.

- The CAD systems needed for VLSI are not likely to be developed by "brute force" methods which would lead to intolerable personnel and computer requirements. The answer must come from the sophistication that developed VLSI itself.

  - Vendors, universities, and government are involved in a massive effort to achieve an order-of-magnitude improvement in CAD methods.

  - Major and rapid changes in CAD systems are expected over the next five years.

- American industry must keep up with leading-edge technology or risk losing business to the Japanese.

EXHIBIT IV-1

TYPICAL RESPONDENTS' COMMENTS
CONCERNING THE ADEQUACY OF
PRESENT VLSI COMPUTER-AIDED DESIGN SYSTEMS

- "Expect major changes of the next five years, the CAD market will respond to user needs."
- "Present designs are not up to the state of the art."
- "Present tools can't cope with the complexity of the newest chips."
- "Systems are primitive."
- "Barely adequate."
- "Do only design layout - 10% of the job."
- "Not geared for VSLI - need more than an auto board and pencil."
- "Need much simpler schematic."
- "Will go more to the direction of system houses with:
  - Simple user graphics
  - Integrated design data base
  - Total integrated verification system"

B. MARKET CHARACTERISTICS

- During the mid-1960s the integrated systems market was driven by military and other large-system requirements; but today the LSI/VLSI industry is clearly driven by the consumer industry's requirements.

  - Matell Industry alone will buy up to 15 million chips per year.

  - System requirements for VLSI are important but will not result in anywhere near the volume that the consumer industry will generate.

  - Total demands for LSI/VLSI devices will continue to support an industry growth of about 20% per year, with the CAD market experiencing a much larger growth over the next 5 years.

- Capital costs for processing equipment (including CAD) are rising steeply.

  - Capital expenditures as a percent of sales for semiconductor companies are expected to be in the 15-20% range this year, and this ratio is expected to continue to rise.

- Semiconductor systems and equipment manufacturers are investing substantially in CAD for LSI/VLSI.

  - Respondents to this study reported that expenditures for electronic CAD were generally running in the vicinity of 1.5% of sales, or 15% of the R&D budget.

  - Among the larger companies, expenditures for CAD were in the $6-10 million-per-year range.

  - All indications are that the LSI/VLSI computer-aided design market will experience explosive growth over the next five years.

- Respondents were asked whether or not they believed that the size of the future electronics CAD/CAM equipment market could be extrapolated from historic sales. Typical comments include:

  - "The market is not straight line - it will explode, then peak."

  - "Expect discontinuous growth."

  - "The market can be extrapolated from the size and complexity of the chips."

  - "The market should grow very rapidly."

- Another significant factor pointing toward discontinuous growth is the fact, pointed out by respondents, that many of the major companies now in the VLSI market are not into CAD in a significant manner now, but they are all getting into CAD in 1980.

- Typical comments concerning the growth of the CAD market for VLSI are:

  - "We have not had a cheering section before. Now that has changed, we have a cheering section pushing hard."

  - "Two years ago, we would have had opposition from top management. That has now disappeared."

  - "CAD is a requirement. Without it, existing products would be impossible and growth obviously would not be considered."

C. MARKET FORECAST

- Three knowledgeable respondents judged the CAD market growth to be from 30-50%.

- Almost all respondents felt that the future CAD market could not be extrapolated from past performance, but rather that there would be discontinuous or "explosive" growth.

- Considering all of these factors, as well as other INPUT research, the growth rate in computer-aided design for LSI/VLSI circuitry is forecast to be an AAGR of 50%.

- The market forecast for LSI/VLSI computer-aided design is shown in Exhibit IV-2.

  - The market is expected to reach $910 million by 1985, a growth over the interim period of 760%.

EXHIBIT IV-2

MARKET FORECAST -
LSI/VLSI COMPUTER-AIDED DESIGN
SYSTEMS AND SERVICES,
SALES IN $ MILLION

YEAR					
1980	1981	1982	1983	1984	1985
$120	$180	$270	$400	$600	$910

AAGR = 50%

V COMPETITIVE ENVIRONMENT

V COMPETITIVE ENVIRONMENT

A. PRESENT USERS

1. EXISTING CAD INSTALLATIONS

- Seventeen CAD installations were reported by the fifteen companies interviewed. Results are shown in Exhibit V-1.

  - Applicon and Calma are regarded as the top LSI/VLSI computer-aided design vendors.

  - Although Computervision is a much larger company, their efforts have, up to now, been concentrated in the mechanical area. They also do not offer a 32-bit word machine, which the industry requires.

  - Control Data Corporation was mentioned once. In this instance, CDC was used for circuit simulation and as backup computing power to another vendor's CAD system on-site.

- The primary applications were for design layout and circuit simulation.

  - The systems are generally being used for their graphics capability.

EXHIBIT V-1

RESPONDENTS' CURRENT
CAD INSTALLATIONS

VENDOR	NUMBER OF INSTAL-LATIONS
APPLICON	8
CALMA	6
COMPUTERVISION	2
CONTROL DATA CORP.	1
TOTAL	17

NUMBER OF RESPONDENTS = 15

- Respondents made limited mention of specific applications, which indicates that present CAD systems can't handle very much of the VLSI design process.

- The natures of the seventeen installations reported were as follows:

  - Freestanding installation 15

  - Computer service 2

  - Interfaced with the host 6

- Users see a general trend toward multiple, on-site, "desk-top" CAD installations with the satellite units interfaced with a host computer or computer service.

- Vendors reported that they were using their own systems for development of next-generation CAD products.

2. APPLICATIONS DEVELOPMENT

- Users are nearly equally divided concerning the desirability of developing electronic applications in-house.

  - This is so due to two major considerations:

    . First, users feel the requirement to protect their proprietary designs by doing internal development, keeping designs out of the hands of vendors.

    . Second, design problems are so acute, and circuit designers so scarce, that most users would like to purchase outside development as much as possible, using their own design resources to advance the state of development and to handle proprietary development.

- The attractiveness of a joint applications development project with a CAD vendor as rated by user companies is shown in Exhibit V-2.

  - Seven of the 13 respondents rated joint development as "very attractive." This is again indicative of users' desires for outside design help.

  - It is also significant that some of the users rated joint development as "unattractive." Some users reported having bad experiences with previous joint development with vendors.

    . These were instances where considerable time and money was expended only to have the results made available to competitors.

    . In one instance, the user would only enter into a joint development if the vendor would promise one-year exclusive rights to the production in order to protect the user's proprietary rights.

B. VENDORS

1. PRESENT VENDORS

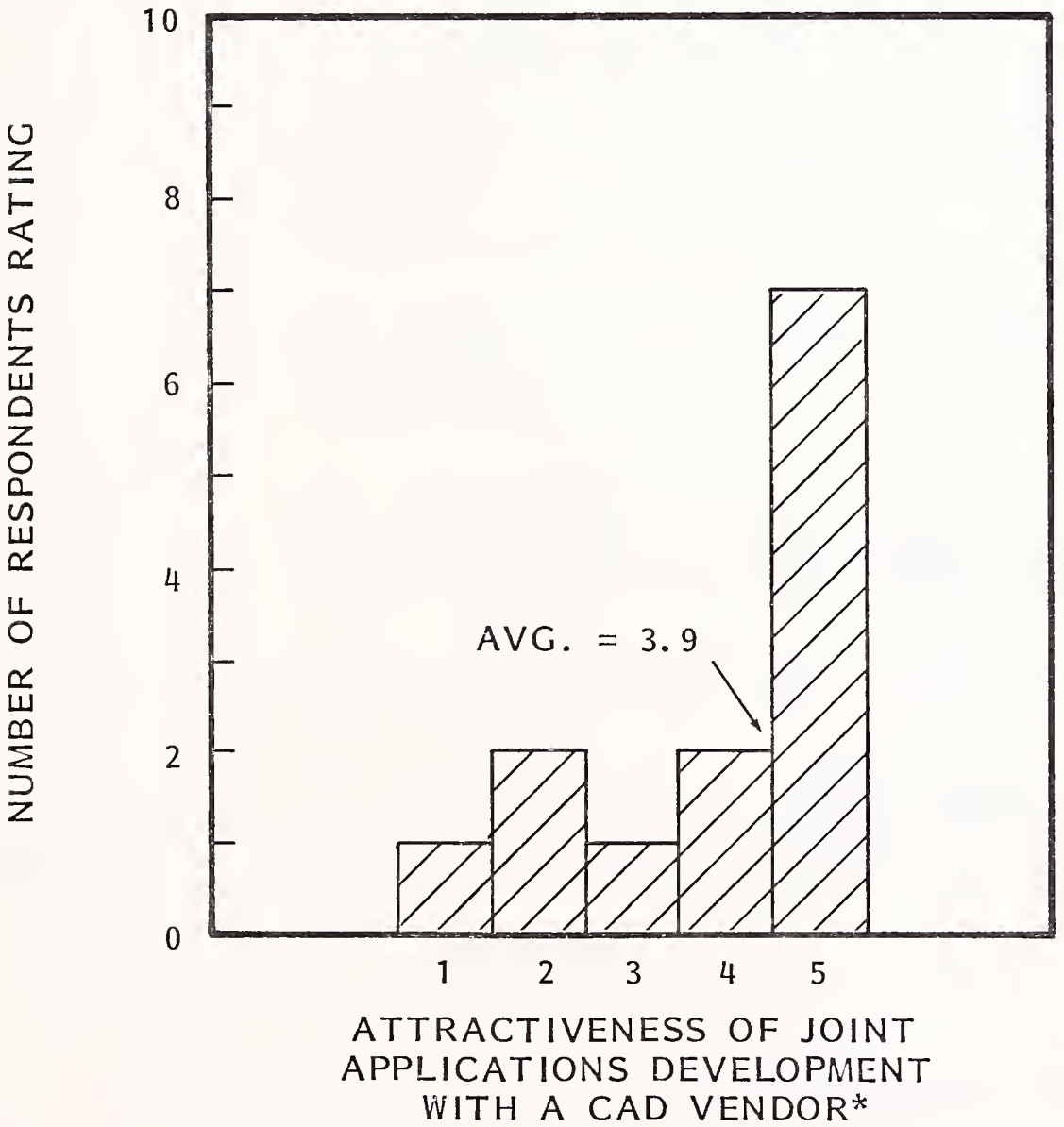
- Respondents rated a list of vendors as suppliers of systems and services, within the context of LSI/VLSI computer-aided design.

  - Ratings of the top three VLSI computer-aided design vendors are shown in Exhibit V-3. They are Calma, Applicon and Computervision in that order.

    . These vendors are relatively well known to respondents and they were rated by an average of 7 users.

EXHIBIT V-2

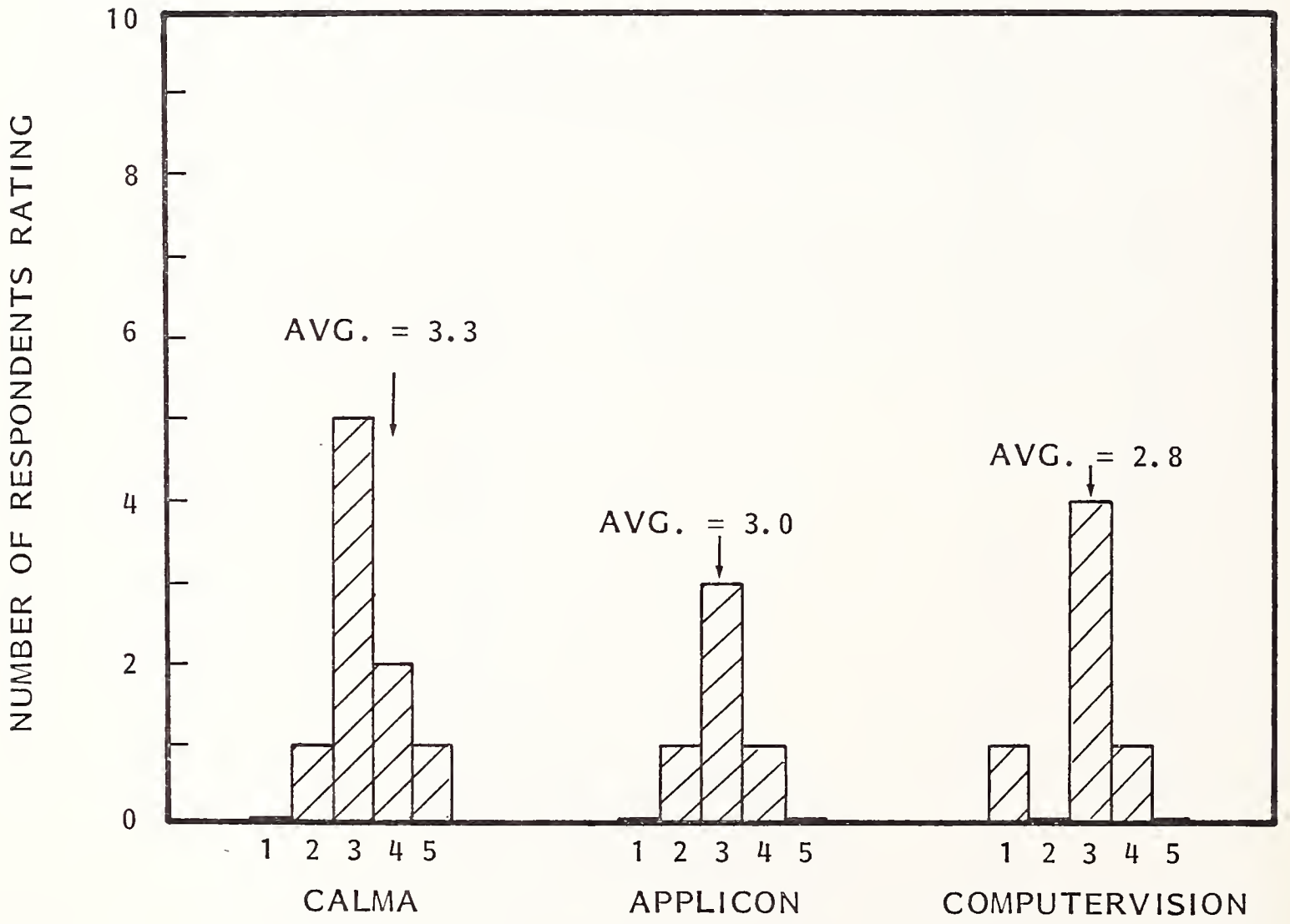
THE ATTRACTIVENESS OF A JOINT
APPLICATIONS DEVELOPMENT PROJECT
WITH A CAD VENDOR AS
RATED BY USER COMPANIES



NUMBER OF RESPONDENTS = 13
*RATED ON A SCALE WHERE 5 IS VERY ATTRACTIVE
AND 1 IS UNATTRACTIVE

EXHIBIT V-3

RESPONDENTS' RATINGS OF VLSI/CAD VENDORS AS SUPPLIERS OF SYSTEMS



NOTE: RATED ON A SCALE WHERE 5 IS EXCELLENT AND 1 IS POOR

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. Calma and Applicon are rated as the leading vendors and are regarded by most as being "neck and neck."

. Computervision has been handicapped in LSI/VLSI CAD by not offering a 32 bit computer. However, Computervision has now made a major committment to LSI/VLSI, 30-50% of a very impressive R&D effort is for electronic design support of LSI/VLSI.

. It is significant to note that none of the three vendors received an outstanding rating, rather they were rated midway between poor and excellent. This again indicates that present systems are not up to the demands of todays chip designs, and leaves plenty of room in the market for companies with superior product offerings.

- Respondents' ratings of equipment vendors as suppliers of systems are shown in Exhibit V-4.

. These vendors were rated by only four users, indicating that users do not often associate these vendors with CAD.

. Again, the ratings were "lukewarm" at best.

. DEC is the OEM supplier to Applicon and is the "hands down" choice of the universities.

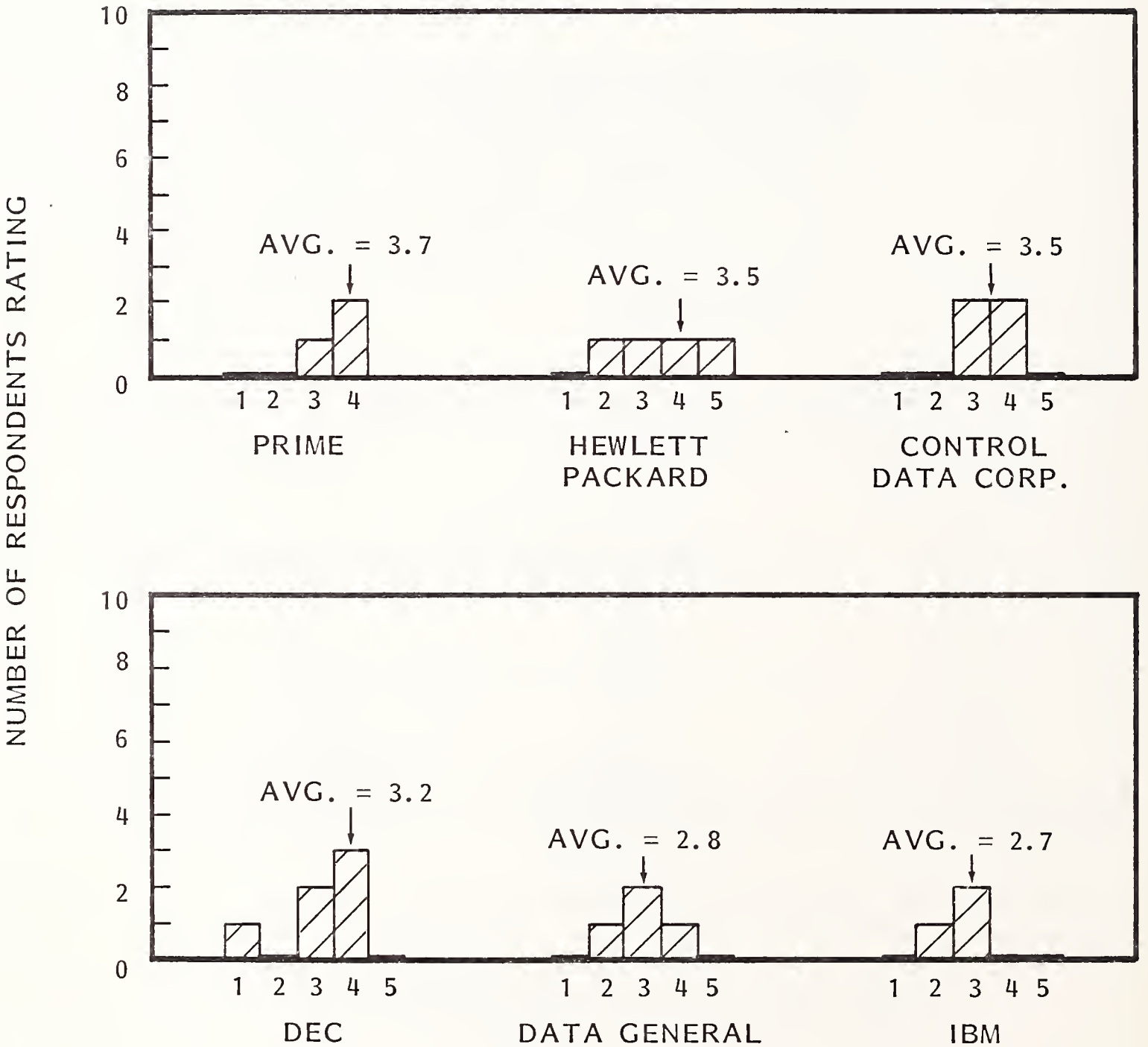
. Data General is the OEM supplier to Calma.

- Respondents' ratings of service vendors as suppliers of remote computing services are shown in Exhibit V-5.

. Although these vendors received relatively high ratings they were only rated by an average of 2 users each, indicating that

EXHIBIT V-4

RESPONDENTS' RATINGS OF COMPUTER VENDORS
AS SUPPLIERS OF SYSTEMS



NOTE: RATED ON A SCALE WHERE 5 IS EXCELLENT AND 1 IS POOR

EXHIBIT V-5

RESPONDENTS' RATINGS OF SERVICES VENDORS
AS SUPPLIERS OF REMOTE COMPUTING SERVICES

SERVICES VENDOR	AVERAGE RATING
CONTROL DATA CORPORATION	3.6
INFORMATION SYSTEMS DESIGN	3.6
NATIONAL CSS	3.3
UNIVERSITY COMPUTING CORPORATION	3.3
UNITED COMPUTING SYSTEMS	3.2
BOEING COMPUTING SERVICES	INSUFFI-CENT DATA
DIGITAL EQUIPMENT CORPORATION	INSUFFI-CENT DATA
TYMSHARE	INSUFFI-CENT DATA

NOTE: RATED ON A SCALE WHERE 5 IS EXCELLENT AND 1 IS POOR
AVERAGE NUMBER OF RESPONDENTS = 4

users make little association with computer services vendors for LSI/VLSI computer-aided design.

2. FUTURE VENDORS

- The computer-aided design market for the LSI/VLSI industry to date has been the province of relatively small companies.

  - However, as larger companies discover that there is a $2 billion market developing at a 40% AAGR over the next 5 years, it is a pretty safe bet that they will be attracted to the market.

- Many companies in the semiconductor industry are watching carefully for any evidence of IBM's interest in the CAD market.

  - Although many users feel that IBM's products are not particularly well suited to the electronic CAD field, IBM is a force to be reckoned with in this field, as in any other.

- Another company that could be a substantial force in the market is Hewlett Packard.

  - HP has all the requisites to be successful in the VLSI computer-aided design market. They have:

    . A well-suited computer line.

    . An excellent internal CAD research and development program.

    . A close connection with university-based research and are currently using university-developed software packages.

    . 70-80% of HP chip design is now being done with first-time circuit designers.

. An effective marketing organization.

- Although rumors of HP entry in the market for CAD are circulating in the industry, HP management maintains a posture that they have no such plans.

  . This position is due, in some large measure, to the belief that the massive research program in the universities will bring about rapid changes in CAD systems which will make it difficult for CAD vendors to keep up.

- Large computer services vendors are expected to enter the market within the 1985 time frame.

  - This is evidenced by CDC's interest in sponsoring this market research effort.

- In summary, INPUT believes that the CAD market for the VSLI industry will see market entry by larger companies within the 1985 timeframe.

3. DESIGN DIRECTIONS

- When total systems go on a chip, collaboration with many more departments, both in semiconductor and end user firms, will be required in order to shape the final product. This will include:

  - Strategic planning.

  - Product planning.

  - Human factors.

  - Applications engineering.

- Industrial design.
- Manufacturing.
- Legal.
- Sales.

- A new style VLSI design company may well emerge.
  - Containing not more than 30-40 specialists.
  - Handling systems applications designs.
  - Farming out VLSI production.

- In any event, INPUT expects the coming 5 year period to be one of fast moving changes in computer-aided design methods for the coming VLSI industry.

C. CAD RESEARCH

1. THE PROBLEM

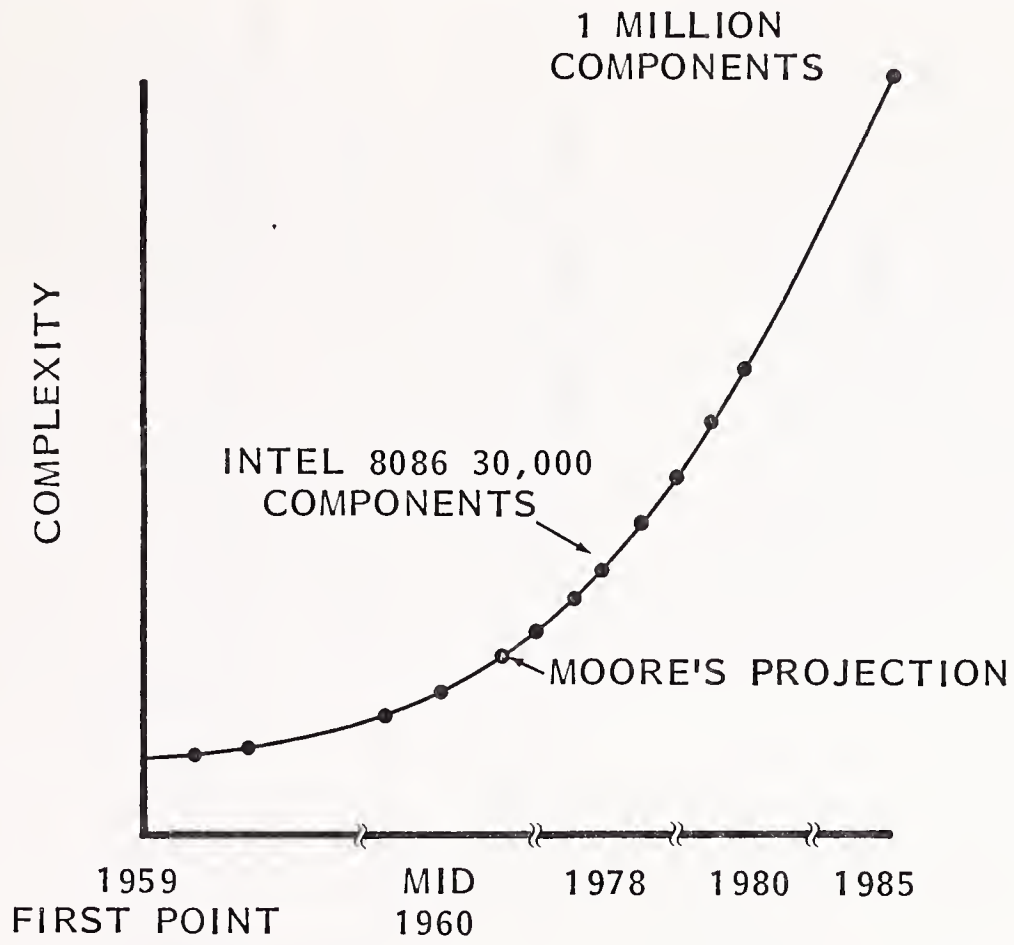
- Simply stated, the problem facing the VLSI industry is one fostered by their own success.
  - The complexity of VLSI chips has outstripped VLSI design methods and future growth could be seriously constrained by present design technology.

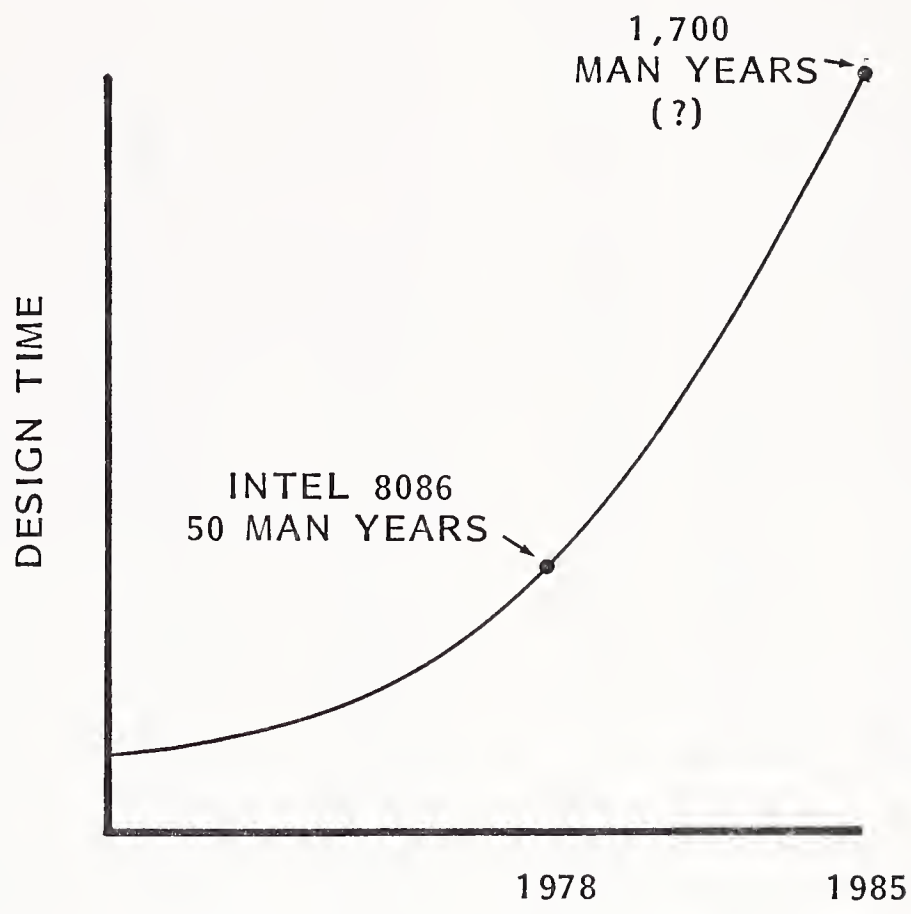
- An axiom of the integrated circuit industry is known as "Moores Law," which is shown in Exhibit V-6.

EXHIBIT V-6

INDUSTRY-WIDE VLSI CAD REQUIREMENTS

MOORE'S LAW: "COMPLEXITY DOUBLES EVERY YEAR"





- In the mid-sixties, Gordon Moore of Intel made the projection that the complexity of integrated circuits would double every year.

- From the first point on the curve in 1959 to present, history has proved Moores law to be correct.

- In 1978, Intel produced a 30,000 component chip with a design effort of 50 man years.

  - At this rate, a 1 million device chip will be feasable by 1985, an exponential increase in complexity.

  - Computer-aided design complexity will have to increase at an even higher exponential rate to handle the design complexity.

- Assuming only an evolutionary, slowly-evolving improvement in CAD methods, this presents two major problems.

  - Required computing power would have to increase by 8 to 16 times.

  - Required design time would increase from 50 to 1700 man years for the design of a single chip, a clearly untenable situation.

- A typical user comment is:

  - "Crack people can design chips now without CAD, but we need CAD so that all designers can make it or we will lose out to the Japanese."

2. RESEARCH APPROACH

- The research and development efforts in industrial firms can be classified as largely evolutionary while those in the universities are aimed at producing revolutionary steps.

- University researchers concluded that the design of tomorrows VLSI chips was too complex for present design tools so they turned to languages, software development, for a solution.

- One basic goal is aimed at decreasing processing time.

  - For example, run a program for an automatic router in minutes rather than hours or days.

- The second basic goal is to dramatically reduce design time and reduce the required sophisication level of VLSI circuit designers so that first-time VLSI designers can handle the design.

- Results of the research effort will be released slowly as it is successful, mostly in the form of software packages.

  - Since the work is largely government funded, results are in the public domain and will be available to CAD vendors.

- Certain industrial firms including Xerox and Hewlett-Packard are tied very closely to this university research.

  - By doing so, they are able to exchange software and keep up with the state-of-the-art.

- The Advanced Research Project Agency and the Air Force are major funding agencies.

- The major universities involved are:

  - Cal Tech.

  - Stanford.

- U. C. Berkeley.
- Carnegie Mellon.
- MIT.
- They meet every six months to compare progress.

- In addition, there are probably another 30 universities involved on a smaller scale.

- As an example, Stanford is establishing a $16 million "Center for Integrated Systems" with an annual operating budget of $5 million a year.

- INPUT believes that this effort involving universities and industry is, in a way, comparable to the effort that established the LSI/VLSI industry in the first place, and that VLSI computer-aided design vendors should plan on major changes over the next 5 years.

- Typical user comments concerning the university research effort are:

  - "Every major university in the nation will be working on CAD, there were 33 new ones in 1978 and 1979."
  - "There is an effort in CAD now like we used to have in developing new products."
  - "The universities will make it tough on CAD vendors, there are 30 universities giving their software away, each takes an area in which to excell."

VI VLSI TECHNOLOGY

VI VLSI TECHNOLOGY

A. STANDARD VERSUS CUSTOM LSI/VLSI DEVICES

- The percentage "Mix" for U.S. industry sales of LSI/VLSI devices that are "custom" versus "off the shelf," as reported by respondents, are shown in Exhibit VI-1.

  - By 1985, about 70 percent of the market will be for standard devices and the rest for custom circuitry.

  - This mix is largely determined by the dominance of consumer applications where off the shelf chips are well suited.

B. CIRCUIT TECHNOLOGY

- The two VLSI technologies, bi-polar and MOS, appear to be converging in speed, performance and even cost. Bi-polar, once faster but costlier and less dense than MOS, has gained in circuit complexity. N-MOS has gained speed and circuit complexity at the expense of increased processing complexity and cost. Meanwhile, C-MOS is catching up with both bi-polar and N-MOS.

  - A summary of VLSI technologies is shown in Exhibit VI-2.

EXHIBIT VI-1

PERCENTAGE "MIX" FOR U.S. INDUSTRY
SALES OF LSI/VLSI DEVICES
THAT ARE "CUSTOM" VERSUS "OFF THE SHELF"

NUMBER OF UNITS-PERCENT		
TYPE	YEAR	
	1980	1985
CUSTOM	50%	30%
OFF THE SHELF	50	70

NUMBER OF RESPONDENTS = 8

EXHIBIT VI-2

VLSI TECHNOLOGY

TECHNOLOGY	COMMENTS
MOS (METAL OXIDE SEMICONDUCTOR)	• DOMINANT TECHNOLOGY
• C-MOS (COMPLIMENTARY)	• DOMINANT TECHNOLOGY BY 1985 BECAUSE OF LOW POWER EQUIPMENT
• N-MOS (N-CHANNEL)/H-MOS	• STRONG NOW BUT WILL GIVE WAY TO C-MOS
• P-MOS	• PHASING OUT
BI POLAR • ECL (EMITTER COUPLED LOGIC) • TTL (TRANSISTOR - TRANSISTOR LOGIC) • I^2L (INTEGRATED INJECTION LOGIC) • ISL (INTEGRATED SCHOTTKY LOGIC)	NO BIPOLAR DEVICE HAS THE IDEAL CHARACTERISTICS OF C-MOS
GALLIUM ARSENIDE (GaAa)	• WHEN PROCESSING PROBLEMS ARE SOLVED, WILL GO BEYOND THE LIMITS OF SILICON TECHNOLOGY.

- N-MOS, and its high-performance successor H-MOS, along with P-MOS are most commonly used in "silicon valley" today.

  - P-MOS is disappearing, but for reasons not always understood.

    . There is nothing wrong with P-MOS for many applications, but suppliers are no longer investing in P-MOS process development or equipment.

  - N-MOS/H-MOS are very strong but will give way to C-MOS by 1985.

- Complimentory - Metal Oxide Semiconductor (C-MOS) will become the dominant technology.

  - C-MOS combines both P-Channel and H-Channel devices on the same N substrate.

  - C-MOS is ideally suited to commercial, telephone and automotive applications because of power requirements. The devices virtually draw no power when in the quiescent state.

  - No bi-polar circuit has the property of C-MOS, that is, using significant amounts of energy only when switching.

  - Power dissipation in present designs is almost at the tolerable limit, the trend in N-MOS designs must be to trade-off speed for lower power dissipation. C-MOS is less restricted this way and will become the dominant technology for VLSI.

- ECL is a standard "work horse" of bi-polar technology but will have to take a back seat because of its "hungry" power requirements.

- The older "standard" TTL circuits are being displaced by Schottky TTL.

VII CAD PRODUCT CHARACTERISTICS

VII CAD PRODUCT CHARACTERISTICS

A. APPLICATIONS AND FEATURES

1. APPLICATIONS

- Respondents ratings of the importance of CAD applications in 1985 are shown in Exhibits VII-1 and VII-2. The rating scale is 5 = critcal and 1 = unimportant.

- Bearing in mind that today's state-of-the-art CAD systems can hardly begin to handle the VLSI design problems, the following rankings clearly set out the objective for research and development efforts.

  . Five applications were rated critical - an average rating of 4.0 or better.

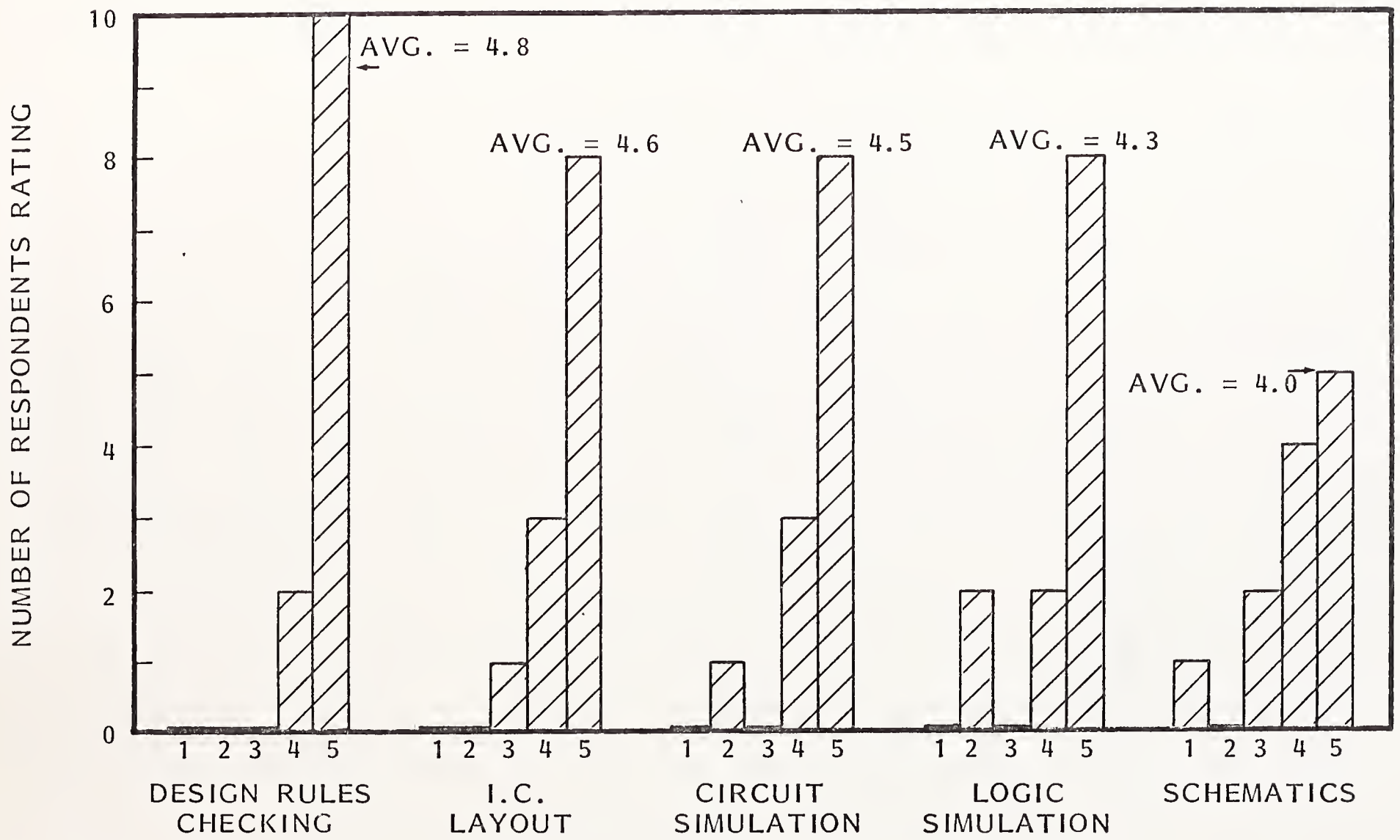
    - Design Rules Checking.
    - I.C. Layout.
    - Circuit Simulation.
    - Logic Simulation.
    - Dependance Upon Schematics.

EXHIBIT VII-1

RESPONDENTS' RATINGS OF THE

IMPORTANCE OF CAD APPLICATIONS

IN 1985



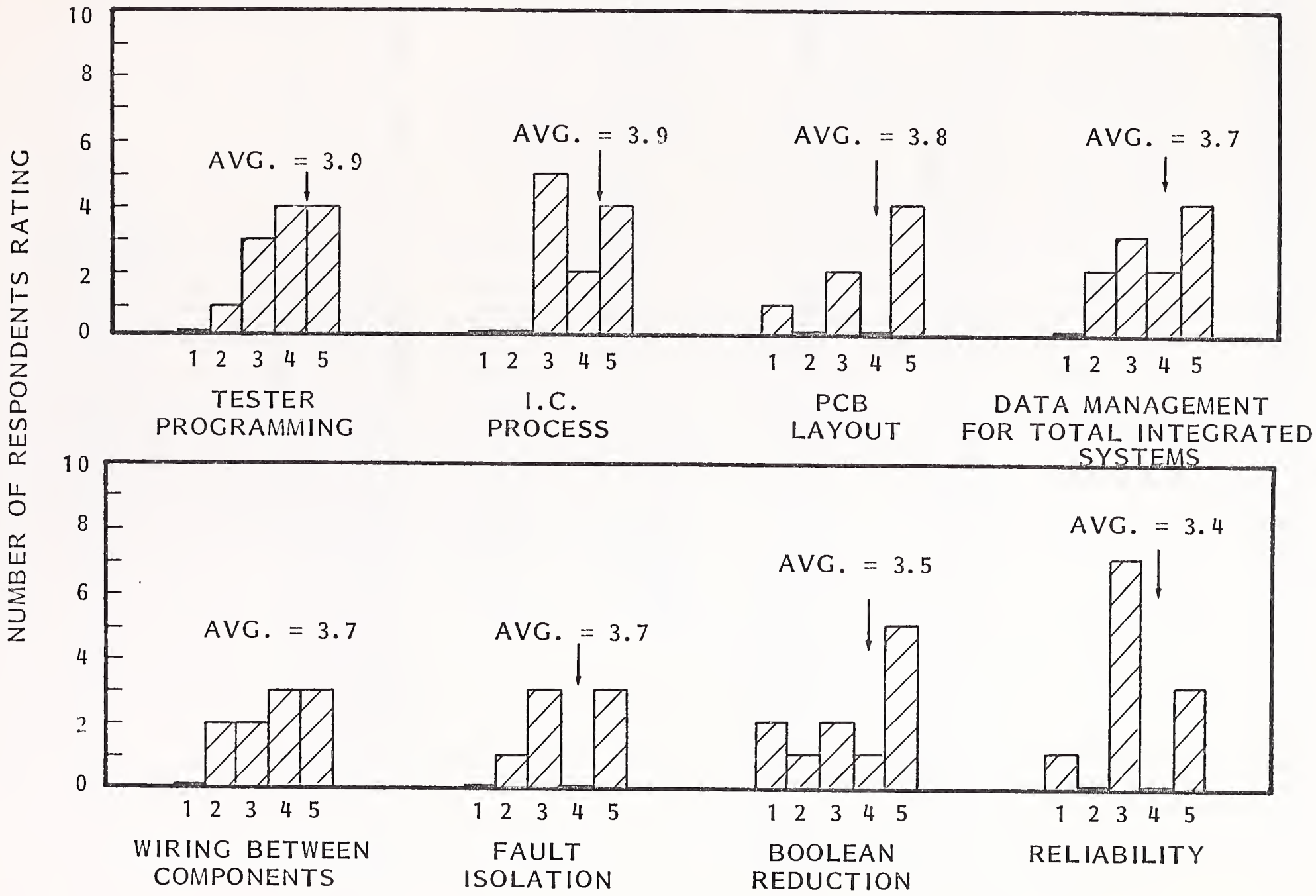
NOTE: RATED ON A SCALE WHERE 5 IS CRITICAL AND 1 IS UNIMPORTANT

INPUT

EXHIBIT VII-2

RESPONDENTS' RATINGS OF CAD APPLICATIONS

IN 1985



NOTE: RATED ON A SCALE WHERE 5 IS CRITICAL AND 1 IS UNIMPORTANT

. The middle grouping of four applications received rather "ho-hum" ratings, certainly far less than critical.

  - Tester Programming - method for programming the test system.

  - I.C. Process - physical composition, cost, changes.

  - P.C.B. Layout.

  - Data Management For Total Integrated Systems - network and data base control by the host.

- It is interesting to note that this group includes data management for total integrated systems, believed to be a key application and a major subject for university research.

. The low rating is believed to be a reflection of a poor understanding as to how to accomplish total integrated systems, rather than a lack of appreciation of the subject.

. One respondent put it succinctly - "no one knows how to do it yet, but everyone thinks it ought to be great."

- The lowest grouping of four applications were rated as not important as compared to other applications.

  - Wiring Between Components - P.C.B., M.B., within circuit.

  - Fault Isolation - ref: logic.

  - Boolean Reduction - design optimization.

- Reliability - prediction capability.

- A comparison of respondents' ratings of the applications for 1980 and for 1985 are shown in Exhibit VII-3.

  - The relative rankings are unchanged from 1980 to 1985.

  - All the ratings, with the notable exception of P.C.B. layout, went up for 1985 as compared to 1980.

  - Sizeable increases in emphasis in 1985 were shown for I.C. process and data management, indicating a growing interest in these two applications.

- For each application rated from important (3) to critical (5), respondents expressed their preference for type of vendor. The results are as follows:

Type of Vendor	Percent Responses
In-House Freestanding System	85%
Computer Services Vendor	15
Outside Designer	0
Total	100%

- Throughout this study respondents have consistently expressed a clear preference for freestanding CAD systems, but they clearly want the system interfaced with a host computer for excess processing power and communications.

2. FEATURES

- Respondents' ratings of important features for CAD applications are shown in Exhibit VII-4.

EXHIBIT VII-3

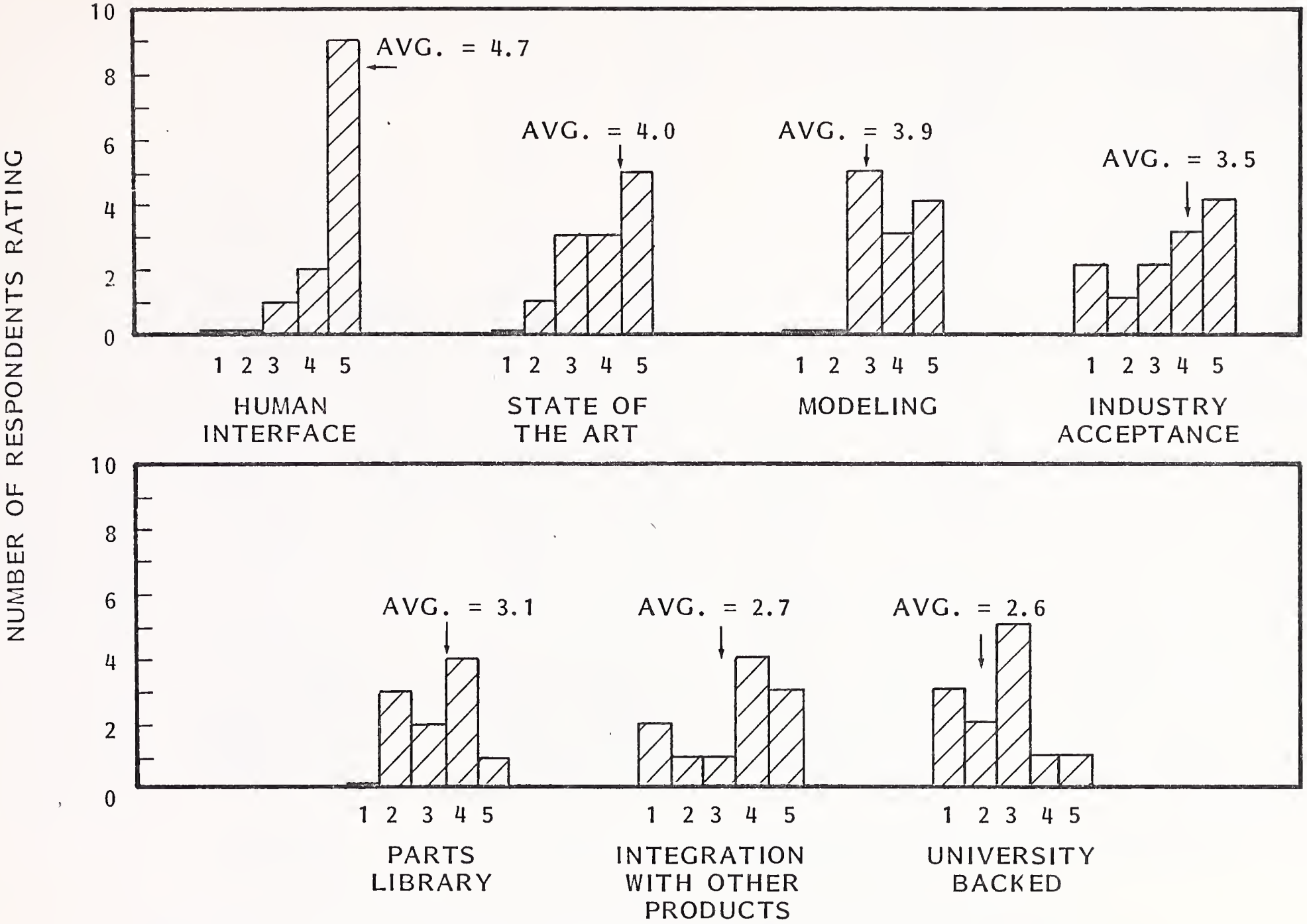
RESPONDENTS' RATINGS OF CAD APPLICATIONS
1980 VERSUS 1985 - AVERAGE RATINGS

CAD APPLICATIONS	AVERAGE RATING	
	1980	1985
DESIGN RULES CHECKING	4.5	4.8
I.C. LAYOUT	4.3	4.6
CIRCUIT SIMULATION	4.4	4.5
LOGIC SIMULATION	4.1	4.3
SCHEMATICS	3.5	4.0
TESTER PROGRAMMING	3.7	3.9
IC PROCESS	3.2	3.9
PCB LAYOUT	4.4	3.8
DATA MANAGEMENT	3.0	3.7
WIRING BETWEEN COMPONENTS	3.3	3.7
FAULT ISOLATION	3.7	3.7
BOOLEAN REDUCTION	3.1	3.5
RELIABILITY	2.8	3.4

NOTE: RATED ON A SCALE WHERE 5 IS CRITICAL AND 1 IS UNIMPORTANT

EXHIBIT VII-4

RESPONDENTS' RATINGS OF IMPORTANT FEATURES OF CAD APPLICATIONS



NOTE: RATED ON A SCALE WHERE 5 IS EXTREMELY IMPORTANT AND 1 IS UNIMPORTANT

- Human interface is rated extremely important because of the vital role that graphics and input-output methods play in the design process.

- State-of-the-art is rated very important because of the fact that today's state-of-the-art is inadequate for VLSI design.

- Industry acceptance is rated as important, but unenthusiastically. Typical user attitudes are, "Why should I care if I run with the crowd, the important matter is performance."

- The lower ratings given to parts library, integration with other products, and university backed applications are intepreted as being comparatively not very important features.

B. IMPORTANCE OF GRAPHICS

- Respondents' ratings of the importance of graphics for various applications for CAD are shown in Exhibit VII-5.

  - For I.C. layout, PCB layout, wiring, and schematics the importance of graphics was rated from very important to extremely important.

    . This is particularly so for I.C. layout which was unanimously rated 5.0 by all respondents.

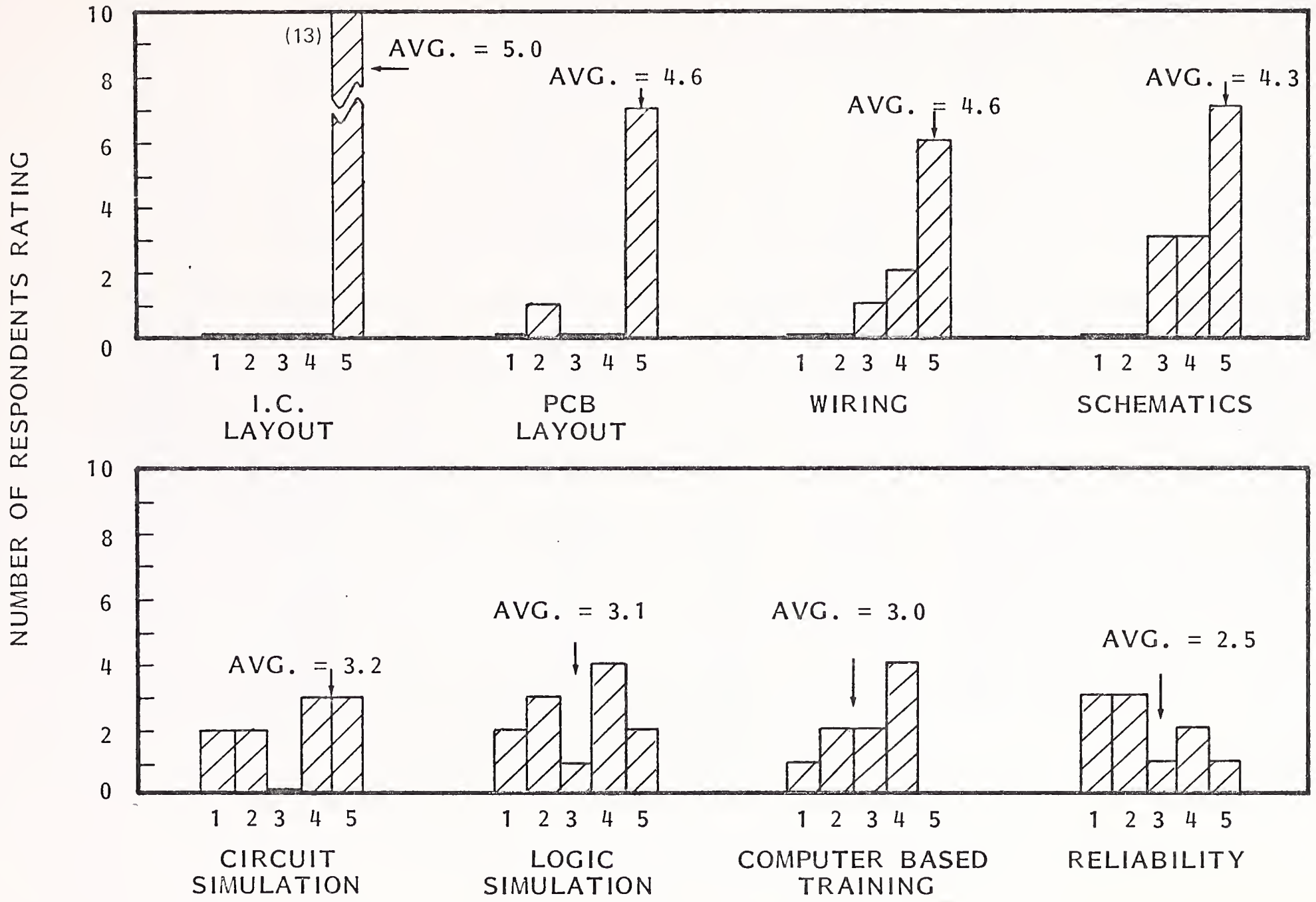
- For the second grouping of applications, circuit simulation, logic simulation, computer based training, and reliability; graphics was rated as important but with no where near the emphasis shown for the first grouping.

- A typical user comment is:

EXHIBIT VII-5

THE IMPORTANCE OF GRAPHICS

FOR VARIOUS APPLICATIONS FOR CAD



NOTE: RATED ON A SCALE WHERE 5 IS EXTREMELY IMPORTANT AND 1 IS UNIMPORTANT

INPUT

- "Graphics is very important from the human engineering viewpoint, but must allow for nonprogramming type users."

- Respondents identified the applications that should be linked together to offer an integrated program, the results are shown in Exhibit VII-6.

  - Clearly, users felt that it is important to achieve an integrated design system and identifiable layout, simulation, and schematics are the most important applications in this regard.

  - However, there were no discernable patterns from the responses as to which applications logically linked to others.

    . This is further evidence of users' uncertainty as to how an integrated system will be achieved.

C. REQUIRED COMPUTER SIZE

- User responses indicate that a 32 bit minicomputer is adequate for VLSI/CAD systems as the industry knows them today and that anything less than 32 bits is inadequate.

- The following user comments are pertinent:

  - "97% of our processing is circuit simulation - 32 bit word size is adequate, it is speed of processing that is the limitation - we need a hiarchy of machines."

  - "All can be processed on a 32 bit super minicomputer (PRIME 750 or VAX 11/780) but load will require multiple minis or access to a large mainframe."

EXHIBIT VII-6

APPLICATIONS THAT SHOULD BE LINKED TOGETHER TO OFFER AN INTEGRATED PROGRAM

APPLICATION	NUMBER OF MENTIONS
I.C. LAYOUT	6
CIRCUIT SIMULATION	6
LOGIC SIMULATION	5
SCHEMATICS	5
RELIABILITY	4
TESTER PROGRAMMING	4
P.C.B. LAYOUT	3
WIRING	3
FAULT ISOLATION	3
COMPUTER-BASED TRAINING	3

- "A 32 bit word suffices for all applications except perhaps certain unique physics measurements - it takes 21 bits now and the memory address system adds 1 bit per year."

- "The problem is to get data from memory - except through a 32 bit channel - there are 10-15 million words of memory and we can get at them one word at a time - like emptying a 50 gallon drum with a teaspoon."

D. CONFIGURATION

- The VLSI industry requires CAD systems that are total integrated systems within the 1985 timeframe.

  - Users visualize multiple CAD installations connected together through 32 bit super minicomputers in a satellite configuration linked to an installed mainframe or remote computing services vendors' central computing facility.

  - With large systems of this sort, there is a clear requirement for data management.

- The following are typical user comments:

  - "It is better to buy CYBERNET time than to buy a CRAY for the 5% of the time it is needed."

  - "The payoff comes with data management."

E. FIELD SERVICE REQUIREMENTS

- Users rated the importance of various factors relating to vendor supplied product support and personnel training.

  - Respondents expectations for field maintenance by systems vendors are shown in Exhibit VII-7.

    . Periodic enhancements and remote diagnostics are regarded by users as being critical.

    . Personal visitation is expected routinely and is regarded to be very important.

    . There is generally not a requirement for a resident on-site except for very large or remote installations. This requirement is also a function of failure rates.

  - Respondents generally ignored the request to rate field maintenance by services vendors.

    . There were comparatively few instances among respondents where field maintenance was provided by services vendors. Ratings by the few respondents are shown in Exhibit VII-8.

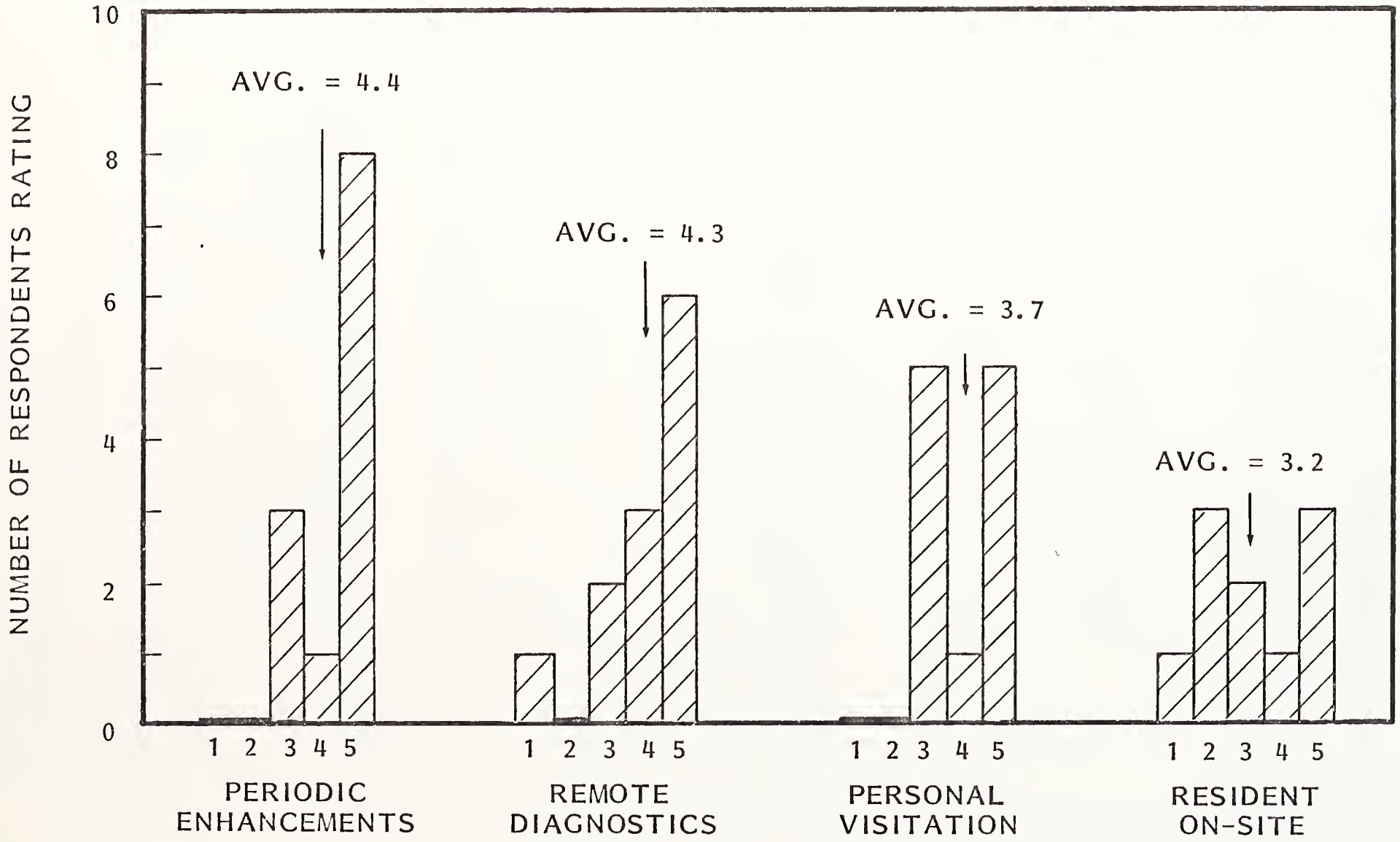
    . As would be expected the importance of remote diagnostics is downgraded for a remote computing services installation as compared to a freestanding installation.

- The amount of operator training required at the start of a program was reported as:

  - Average: 25 man days.

EXHIBIT VII-7

RESPONDENTS' EXPECTATIONS FOR
FIELD MAINTENANCE -
BY SYSTEMS VENDORS



NOTE: RATED ON A SCALE WHERE 5 IS CRITICAL AND 1 IS UNIMPORTANT

INPUT

EXHIBIT VII-8

RESPONDENTS' EXPECTATIONS FOR FIELD MAINTENANCE - BY SERVICES VENDORS

METHOD	AVERAGE RATING
PERIODIC ENHANCEMENT	4.3
PERSONAL VISITATION	3.8
REMOTE DIAGNOSTICS	3.0
RESIDENT ON-SITE	2.5

NOTE: RATED ON A SCALE WHERE 5 IS CRITICAL AND 1 IS UNIMPORTANT

AVERAGE NUMBER OF RESPONDENTS RATING = 3

- Range: 5 to 65 man days.

- The expected mean time to repair was reported as:

  - Average: 4 hours.

  - Range: 2-24 hours.

APPENDIX A: DATA BASE

EXHIBIT A-1

CAD INTERVIEW PROGRAM

INTERVIEW TYPE	NUMBER OF RESPONDENTS	TELE-PHONE / ON-SITE	SIZE OF COMPANY		
			SMALL	MEDIUM	LARGE
VENDOR	2	– / 2	1	1	–
USER	13	3 / 10	3	7	3
TOTAL	15	3 / 12	4	8	3

SMALL = < $100 MILLION REVENUE
MEDIUM = $100 - $1,000 MILLION
LARGE = > $1 BILLION

EXHIBIT A-2

MARKET FORECAST -
LSI/VLSI COMPUTER-AIDED DESIGN
SYSTEMS AND SERVICES,
SALES IN $ MILLION

YEAR					
1980	1981	1982	1983	1984	1985
$120	$180	$270	$400	$600	$910

AAGR = 50%

APPENDIX B: DEFINITIONS

APPENDIX B: DEFINITIONS

BATCH SERVICES This includes data processing performed at vendors' sites of user programs and/or data which are physically transported (as opposed to electronically by telecommunications media) to and/or from those sites. Data entry and data output services, such as keypunching and COM processing, are also included. Batch services include those expenditures by users which take their data to a vendor site which has a terminal connected to a remote computer used for the actual processing.

BYTE Approximately equivalent to the storage required for one alphanumeric character (i.e., one letter of number).

CENTRAL PROCESSING UNIT (CPU) The arithmetic and control portion of a computer; i.e., the circuits controlling the interpretation and execution of computer instructions.

COMPUTER SERVICES Those services provided by vendors which perform data processing functions using vendor computers, or assist users to perform such functions on their own computers.

DATA BASE MANAGEMENT SYSTEM A generalized computer program which handles the mechanics of storing, updating and accessing data for multiple applications. This definition does not include file management systems which are designed primarily for single applications (e.g., MARK IV, EASTRIEVE).

- DISTRIBUTED DATA PROCESSING (DDP)

  - INPUT was unable to find a consensus among both users and vendors as to a definition of DDP. It appears to be a concept that is uniquely structured to satisfy individual vendor and user requirements.

  - Nonetheless, as a result of extensive work in this area, INPUT offers the following hybrid definition:

    "Distributed processing is the deployment of programmable intelligence in order to perform data processing functions where they can be accomplished most effectively, through the electronic interconnection of computers and terminals, arranged in a telecommunications network adapted to the user's characteristics."

ELECTRONIC MAIL A range of services which transmit documents consisting of text and graphic material to be read by a person - the quality of the document will be high.

END USER May buy a system from the hardware supplier(s) and do its own programming, interfacing and installation. Alternately, it may buy a turnkey system from a systems house or hardware integrator.

EQUIPMENT COMPATIBILITY A service which allows information to be interchanged among equipment from different manufacturers, and among equipment of different types - terminals, facsimiles, and mainframes are all included.

FACILITIES MANAGEMENT (FM) (Also referred to as "Resource Management" or "Systems Management.") The management of all or part of a user's data processing functions under a long-term contract (not less than one year). To qualify as FM, the contractor must directly plan and control as well as operate the facility provided to the user on-site, through communications lines, or mixed mode. Simply providing resources, even though under a long-term contract and/or for all of a users' processing needs, does not necessarily qualify as FM.

GENERAL PURPOSE COMPUTER SYSTEMS A computer designed to handle a wide variety of problems; includes machine room peripherals, systems software, and small business systems.

INFORMATION PROCESSING Data processing as a whole including use of business and scientific computers.

INSTALLED BASE Cumulative number or value (cost when new) of computers in use.

MEAN TIME TO RESPOND The elapsed time between the user placement of a service call and the arrival at the user's location of a field engineer.

MEAN TIME TO REPAIR The elapsed time from the arrival of the field engineer on the user's site until the device is repaired and returned to the user for his utilization.

MEAN TIME BETWEEN FAILURES (MTBF) The elapsed time between hard failures on a device or a system.

MESSAGE A communication intended to be read by a person. The quality of the received document does not have to be high - only readable. Graphic material is not included.

MICROCOMPUTER Combines all of the CPU, memory and peripheral functions of a computer on a chip of silicon. It may be sold in an integrated circuit package or with the addition of more memory and peripheral circuits packaged on a board of a console. Eight bit computer on a chip used as a component.

MINICOMPUTER Usually a 12 to 16 bit computer which is provided with limited applications software and support and represents a portion of a complete, large system.

MULTIPLE DISTRIBUTION A message is transmitted to many locations either pre-selected or listed at time of transmission.

PERIPHERALS Includes all input, output, and storage devices, other than main memory, which are locally connected to the main processor and are not generally included in other categories, such as terminals.

PROCESSING SERVICES Processing services encompass FM, RCS, and batch services. They are categorized by type of service, as distinguised from mode of service, bought by users as follows:

GENERAL BUSINESS services are processing services for applications which are common to users across industry categories. Software is provided by the vendor; this can be a complete package, such as a payroll package, or an application "tool," such as a budgeting model, where a user provides much of the customizing of the finished product it uses. General business processing is often repetitive and transaction oriented.

SCIENTIFIC AND ENGINEERING services are the processing of scientific and engineering problems for users across industries. The problems usually involve the solution of mathematical equations. Processing is generally problem solving and is non-repetitive, except in the sense that the same packages or "tools" are used to address different, but similar problems.

INDUSTRY SPECIALTY services provide processing for particular functions or problems unique to an industry or industry group. The software is provided by the vendor either as a complete package or as an application "tool" which the user employs to produce its unique solution. Specialty applications can be either business or scientific in orientation; data base services where the vendor supplies the data base and controls access to it (although it may be owned by a third party) are also included under this category. Examples of industry specialty applications are: seismic data processing, numerically-controlled machine tool software development, and demand deposit accounting.

UTILITY services are those where the vendor provides access to a computer and/or communications network with basic software that enables any user to

develop its own problem solution or processing system. These basic tools include terminal handling software, sorts, language compilers, data base management systems, information retrieval software, scientific library routines, and other systems software.

DBMS REVENUES include all revenues directly relating to the processing and storing of data which interacts with the data base management system, as well as programming and training charges related to DBMS application development and usage. Not included as DBMS revenues are pull-through revenues, such as processing charges for the use of other software to manipulate data extracted from the data base management system, or revenue obtained from operating a data base management system purchased by one customer and run exclusively for him.

DATA BASE MANAGEMENT SYSTEM SERVICE provides to a user, for a fee, a data base management system through a Remote Computing Service (RCS).

PROPRIETARY DBMS is a DBMS developed by the RCS vendor or acquired from an external group not actively marketing it as a software product.

THIRD PARTY DBMS is a DBMS developed by someone other than the RCS vendor and marketed by that of another organization as a software product.

PROPRIETARY DBMS VENDOR is one which has a majority of its DBMS revenues from Proprietary DBMS.

THIRD PARTY DBMS VENDOR obtains a majority of its DBMS revenues from Third Party DBMS

PROFESSIONAL SERVICES Management consulting related to EDP, systems consulting, systems design and programming, and other professional services are included in this category. Services can be provided on a basis of: "Time and Materials," whereby the user pays for the time used of an individual on a daily or other fixed rate, or "Fixed Price," where the user pays a fixed fee for a specific task or series of tasks.

REMOTE COMPUTING SERVICES (RCS) Provision of data processing to a user by means of terminals at the user's site(s) connected by a data communications network to the vendor's central computer. There are three sub-modes of RCS:

INTERACTIVE (timesharing) is characterized by interaction of the user with the system, primarily for problem solving timesharing, but also for data entry and transaction processing; the user is "on-line" to the program/files.

REMOTE BATCH is where the user hands over control of a job to the vendor's computer which schedules job execution according to priorities and resource requirements.

DATA BASE is characterized by the retrieval of information from a vendor-maintained data base. This may be owned by the vendor or a third pary.

REMOTE COMPUTING SERVICES (RCS) REVENUES are those revenues obtained by the provision of data processing to a user by means of a terminal at the user's site(s). The terminal is connected by a data communications network to the vendor's central computer. Not included as RCS revenues are sales to captive companies (i.e., companies which are part of the same corporate entity as the vendor).

SIC Standard Industrial Classification. Developed for use in classifying establishments by type of activity to facilitate and promote uniformity, as well as comparability, in the collection and presentation of statistical data on economic activities.

SMALL BUSINESS COMPUTER For the purpose of this study, it is a system which is built around a Central Processing Unit (CPU), and which has the ability to utilize at

least 20M bytes of disk capacity, to provide multiple CRT work stations, and to offer business-oriented system software support. Minicomputer based system used for general business data processing and for specialized industry oriented business applications.

SOFTWARE Computer programs.

SOFTWARE PRODUCTS This category is for users' purchases of systems and applications packages for use on in-house computer systems. The figures quoted include lease and purchase expenditures, as well as fees for work performed by the vendor to implement and maintain the package at the users' sites. Fees for work performed by organizations other than the package vendor are counted in professional services. There are two sub-categories:

> SYSTEMS PACKAGES OR SYSTEMS SOFTWARE are operating systems, utilities, and languages routines that enable the computer/communications system to perform basic functions. This software is provided by the mainframe manufacturers with their hardware; other vendors provide improved versions of this and special-purpose routines. This classification includes compilers, data base management software, diagnostic software, and sorts.
>
> APPLICATIONS PACKAGES OR APPLICATIONS SOFTWARE are software which perform processing to serve user functions. They consist of general purpose packages, such as accounting and inventory control, and special purpose packages, such as personal trust, airline scheduling, and demand deposit accounting.

SYSTEMS ANALYST Individual who analyzes problems to be converted to a programmable form for application to computer systems.

SYSTEMS HOUSE Integrates hardware and software into a total turnkey system to satisfy the data processing requirements of the end user. It may also develop system software products for license to end users.

- USER SITE HARDWARE SERVICES (USHS)

  - Place intelligent hardware (i.e., terminals, microcomputers, minicomputers) at the user's site or at the vendor's site dedicated to the user.

  - Offer significant RCS vendor-supplied software for execution on vendor-supplied intelligent hardware.

  - Offer user access to the RCS vendor's communications network.

  - Offer user access through the vendor's RCS networks to the vendor's mainframes or other intelligent hardware supplied to the user by the vendor.

VALUE ADDED NETWORK (VAN SERVICES) are the regulated communications network services that offer more than simple point-to-point connections.

APPENDIX C: QUESTIONNAIRE

CATALOG NO. Y C A D ☐ ☐ ☐

COMPUTER AIDED DESIGN

USER QUESTIONNAIRE

- The primary objectives of the study are to determine the projected market through 1985 for Computer Aided Design (CAD) services and systems used for the design of LSI/VLSI devices.

  - Another objective of the study is to determine what CAD methods are currently being employed by LSI circuit designers today, and to obtain users' perceptions of what they would prefer as well as the new methods that will be available in the forecast timeframe.

1. Are you currently using or planning to use CAD?

   ☐ Yes ☐ No

   a. If no, terminate the interview.

2. Please list the primary applications you are using CAD for:

   _____

   _____

   _____

   _____

   _____

3. Is your CAD a:

   ☐ Computer service

   ☐ Freestanding installation

   ☐ Other

   Please describe your installation:

   _____

   _____

   _____

   _____

4. Do you believe that historic and presently used CAD/CAM methods are adequate for designing LSI/VLSI devices now and in the future?

☐ Yes ☐ No

a. Why?

_____

_____

_____

_____

5. Do you believe that the size of the future electronics CAD/CAM equipment market can be extrapolated from historic sales?

☐ Yes ☐ No

a. Why?

_____

_____

_____

_____

b. What will the average annual growth rate be from 1980 to 1985?

_____ %

c. Do you believe electronic applications should be developed internally?

☐ Yes ☐ No

INP

6. What do you believe will be the percentage "mix" as measured by the number of units/part numbers, for the following U.S. industry sales of VLSI/LSI devices?

VSLI/LSI Devices	1980	1985
	Units/Part Nos.	Units/Part Nos.
Custom	/	/
Off Shelf	/	/
Total	100% / 100%	100% / 100%

7. Which of the following circuit technologies will have dominance in your company, and what is the percentage mix for the years indicated?

Technology	Dominant (X)	Year	
		1980	1985
a) ECL		%	%
b) C-MOS			
c) P-MOS/N-MOS			
d) I^2 L Family			
e) T^2 L Family			
f) C-MOS/SOS			
Total		100%	100%

8. Please rate, by importance to your company, the applications listed for the years 1980 and 1985. (1 = unimportant, 5 = critical)

Application	Year			
	1980		1985	
	Rating	Mode* of Delivery (a,b,c)	Rating	Mode* of Delivery (a,b,c)
a) Circuit Simulation				
b) Logic Simulation				
c) I.C. Layout				
d) P.C.B. Layout				
e) Tester Programming (Method for programming test system)				
f) Wiring Between Components (PCB, MB, within circuit)				
g) Fault Isolation (Ref.: logic)				
h) Boolean Reduction (Design optimization)				
i) Design Rules Check				
j) Reliability (Prediction capability)				
k) I.C. Process (Physical composition, cost, etc. changes)				
1) Schematics (Dependence upon)				
** m) Data Management for Total Integrated Systems (Network and D.B. control by host)				

*For each of the applications rated from important (3) to critical (5) would you prefer using: (a) in-house freestanding system, (b) computer services vendor, or (c) outside designer.

**Key question

INP

9. What expenditure level expressed in thousands of dollars ($000s) and as percentage of the total budget will your company spend on electronic CAD in:

   a. 1980 ($000) _____ % of R&D _____

   b. 1985 ($000) _____ % of R&D _____

10. a. How would your company perceive the attractiveness of a joint applications development project with a CAD vendor? (1 = unattractive, 5 = very attractive)

   Rating _____

   b. If rated attractive (3) to very attractive (5), which applications are most suitable? (refer to Question #8)

_____

_____

_____

_____

11. Which, if any, applications of importance to you require processing capacity greater than a 32 bit minicomputer to perform? (refer to Question #8) Why?

_____

_____

_____

_____

_____

_____

12. How do you rate (1 = poor, 5 = excellent) the following vendors as suppliers for:

a.	Systems	CDC	_____
		Calma	_____
		Computervision	_____
		DEC	_____
		Data General	_____
		Hewlett-Packard	_____
		IBM	_____
		Prime	_____
b.	Services	BCS	_____
		CDC	_____
		DEC	_____
		ISD	_____
		NCSS	_____
		Tymshare	_____
		UCC	_____
		UCS	_____

13. a. Please rate the importance of graphics for the applications listed. (1 = unimportant, 5 = extremely important)

Application	(a) Rating	(b)
Circuit Simulation		
Logic Simulation		
I.C. Layout		
P.C.B. Layout		
Wiring		
Reliability		
Schematics		
Tester Programming	N/A	
Fault Isolation	N/A	
Computer-Based Training		

b. Indicate which applications should be linked together to offer an integrated program so as to better coordinate your company's manufacturing needs and capabilities.

Comments:

14. How do you rate the importance of the following features for CAD applications? (1 = unimportant, 5 = extremely important)

Feature	Rating
Modeling	
Part Library	
Human Interface	
State-of-the-Art	
Industry Acceptance	
University Backed	
Integration with Other Products	

INP

15. Indicate your expectations from a systems or services vendor for personnel training and product support by rating the following factors: (1 = unimportant, 5 = critical)

Factor	Rating	Rating
	Systems Vendor	Services Vendor
a. Maintenance of software by vendor field engineering organization through:		
- Personal visitation	_____	_____
- Remote diagnostics	_____	_____
- Periodic enhancements	_____	_____
- Personnel resident on-site	_____	_____

b. How much operator training do you think is required at the start of the program?

_____ Man-days

c. What mean time to repair do you expect?

_____ Hours